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# THE IMPACTS OF STANDARD GAUGE RAILWAY ON THE DIVERSITY OF FLORA AND FAUNA: A CASE STUDY OF PUGU HILL FOREST RESERVE

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**Abstract:** *The development of the Standard Gauge Railway (SGR) is a transformative infrastructure project designed to enhance economic growth, connectivity, and accessibility in Tanzania. However, its construction and operation pose significant challenges to the biodiversity of flora and fauna, particularly in ecologically sensitive areas like the Pugu Hills Forest Reserve. This study investigates the environmental impacts of the SGR, focusing on habitat loss, species diversity decline, and wildlife migration disruption. It highlights the reserve's critical role in preserving unique flora and fauna, including endemic and endangered species. The findings emphasize the need for comprehensive environmental impact assessments and sustainable mitigation measures to balance development and conservation.*

**Key words:** Standard Gauge Railway (SGR), Pugu Hills Forest Reserve, Biodiversity, Wildlife Corridors, Habitat Fragmentation

**Introduction**

The SGR will be a single-track electrified railway for a design speed of 160 km/h for passenger trains and 120 km/h for freight trains. The maximum train length will be 2000 m with a passenger capacity of 1.1 million passengers per year. The SGR rail width of the SGR is 1435 mm (4ft 8½ in), as compared to the narrower 1000 mm (3ft 3in) width of the existing MGR line. This means that the SGR can handle larger/heavier trains and at faster speeds. The SGR will be elevated above-ground for the first part of its route through Dar es Salaam. Approximately 51 km of Lot 1 (Dar es Salaam to Morogoro) and the entire Lot 2 (Morogoro - Dodoma - Makutupora) will be fenced along the alignment, both on the left and the right side. Additionally, for Lot 1, fencing will be in place in urban areas, around passenger stations, freight facilities and marshalling yards to prevent pedestrian access onto the track facilities. (TRC, 2019) SGR is expected to boost local economy/ economic growth through improved connectivity within and outside the country's borders and improved access to markets. Increased capacity of the central railway yielding lower Transport costs & shorter travel times – avoiding truck traffic on the roadway (TRC, 2019), Also Employment Opportunities, both direct and indirect yielding increased money circulation/ income situation, Improved access to social services for residents, Improved agriculture through better access to farming inputs, as well as Increased socio-cultural interaction (Ndambuki, 2023). In other hand it may have negative impacts such as Pollution, Soil erosion, Loss of natural habitat, Noise and vibration ,Air pollution and Greenhouse Gas emissions, Safety and health risks, Increased Wastes, Increased water abstraction and pressure on water resources (Andeso, 2019).

The proposed SGR route passes along various wildlife protected areas such as Pugu hills nature reserve, Ruvu South Forest reserve and Dindili Forest reserve. It also passes along some wildlife habitats named, Northern Zanzibar-Inhambane Coastal Forest Mosaic; Eastern Miombo Woodlands; Zambezian Flooded Grasslands; and Southern Acacia-Commiphora Bushlands and Thicket. It passes along some faunal communities and wildlife corridors where's TAWIRI report (2009) describes 31 wildlife corridors within Tanzania, of which two corridors are intersected by the SGR, namely between the Mikumi National Park and the Wami Mbiki Wildlife Management Area (WMA) and between the Selous Game Reserve and the Wami Mbiki WMA (Jones et al, 2012). A field survey was conducted to confirm the existence of these wildlife corridors, determine the likely wildlife species involved, and investigate the possible seasonality of movement patterns. The study also investigated the permeability of the SGR to develop an opinion on the severity of wildlife fragmentation impacts(Riggio & Caro, 2017).it's believed that the SGR will have major impacts on diversity of flora and fauna over all these occasions.

The Pugu Hills Forest Reserve protects one of the most important remnants of Coastal Dry Forest, with very high diversity of species. This forest is an important 'stepping stone' for forest-dependent migratory birds such as the Spotted Ground-thrush and the Sokoke Pipit. The Rondo Dwarf Galago is a critically endangered primate that has its largest population here. This little primate has been recorded in tiny isolated populations north of Dar es Salaam and in the vicinity of Lindi, and qualifies as a near-AZE species. The forest is generally supporting two endemic mammal species, and one endemic bird. Wildlife remaining there includes elephant, hippopotamus, giraffe, impala, common warthogs, leopard, cheetah, spotted hyena, side-striped and black-backed-jackals, pangolins, elephant shrew, mongoose, civets, baboons, galagoes, colobus monkeys, as well as over 80 species of birds(Madenge, 2021). The protected area is small and surrounded on a few sides by communities, yet the KDCF IBA description confirms there is a population of elephants that may well move between this site and the northern approaches of the Selous Game Reserve.

**Statement of the Problem**

Construction practices they highly contribute to the removal of natural habitat which affects the diversity of individual specie, genetic diversity and somehow prevents migration and occupation of wide range of habitat. In particular, transport infrastructures such as Standard gauge railway over the past few decades has cause major impact on wildlife population and diversity worldwide, causing habitat loss, pollution and fragmentation. For that reason, Detailed impact assessments of proposed railway infrastructure projects are thus essential prior to their initiation (Roy & Mitra, 2016).

**Justification of the Study**

Although many studies on construction projects with their impacts on flora and fauna have been conducted, fewer have considered assessment of impacts on diversity of flora and fauna at and near certain construction project. This research target at assessing impact caused by standard gauge railway on diversity of flora and fauna across Pugu hill forest reserve. There is need to have a criterion for assessing the impacts of construction projects on biodiversity (Muwanika et al, 2017). It may then be used by construction agencies, contractors and concessionaires to make good plan of various construction projects with less negative impacts to flora and fauna (Ledec & Posas, 2003)

**Objectives**

**General Objectives**

- To assess the impacts of standard gauge railway ( SGR) on the diversity of flora and fauna across Pugu hill forest reserve.
- To evaluate abundance of species in 200m away from railway line.
- To evaluate species diversity and richness of 200m away from railway line.
- To evaluate species distribution within 200m away from the railway line.

**Literature Review**

Standard Gauge Railway construction in Tanzania resulted to adversely impacts on the diversity of flora and fauna but with potentially benefits for the economic development of the country. Railway located within the protected area can adversely affect the preservation of the protected area. Even with good planning, proper technology implementation and tight protected area supervision of the impacts can be minimized, the protected areas will still experience changes in the physical and chemical conditions of the area that ultimately affect the lives of flora and fauna in the protected area. (Isworo & Oetari, 2017).Flora and fauna are the collections of all plants (flora) and animals (fauna) living in a particular region that interact in various ways to form an ecosystem( McCollum & Amanda ,2023).Fauna includes list of mammals, reptiles and amphibians which are likely to occur at the site were derived based on distribution records from the literature and the ADU databases (Reptile Map, Frogmap and MammalMap) http://vmus.adu.org.za.Examples of flora include Examples of flora include: trees, such as chestnut; shrubs, such as roses; and grasses( McCollum & Amanda, 2023). It has been reported that railway operations contribute to air and noise pollution, adversely impacting human societies and wildlife populations (Roy; 2023). Emissions originating from locomotives and construction equipment result in an increase in air pollutants, including particulate matter (PM), nitrogen oxides (NOx), and volatile organic compounds (VOCs).These pollutants compromise air quality, endanger human health, and negatively affect vegetation. Construction and operation of railways can also lead to alterations in water resource dynamics due to changes in hydrological patterns, an increase in stormwater runoff, and the risk of contamination (Nikolić et al., 2016),habitat fragmentation, introduction of invasive species and habitat loss and climate change. Furthermore, land requisitions for railway construction may culminate in the obliteration of agricultural lands, imparting negative repercussions on local communities and jeopardizing food security (Macura et al., 2022).Across many construction projects, and especially infrastructure projects, efforts to mitigate potential loss of biodiversity and habitat are significant concerns, Construction activity can be extremely disruptive or damaging to animal habitats and wildlife itself (Sage at el.,2019) In the construction of railway, it is needed a comprehensive study to ensure that an ecological balance between development and the environment will be impacted (Oldfield S, 1998). The environmental impact assessment is a tool for planning, management, monitoring and evaluation of the environment due to an activity so comprehensively between development activities and the environment runs in harmony (Jakarta, 1999). According to English Oxford dictionary "Diversity" defined as the state of being diverse; variety. One of the factors likely to be affected by the construction of the railway is the condition of diversity of flora and fauna, especially diversity of endemic species that founded in particular protected area.

It is surprising, therefore, that animals and their habitats (or 'wildlife') have not been studied more extensively within the construction project management field. Indeed, with a few recent exceptions (Sage et al, 2011; Tryggestad et al, 2013). Considerations pertaining to land use, habitat fragmentation, air and noise pollution, water resources, and biodiversity conservation are integral to this analysis. Comprehending the ecological impacts of this standard Railway Gauge is instrumental in facilitating informed decision-making and devising efficacious conservation strategies. Additional research coupled with an extensive environmental susceptibility study are warranted to ensure the sustainable development of the railway corridor, concurrently minimizing ecological degradation ( Roy, 2023)

**Methodology**

**Description of the Study Area**

The Pugu Hills Forest Reserve is a protected forest area which located located at Kisarawe District in the Coast (Pwani) Region in Tanzania. It was gazetted in 1947 and covers a land surface area of 23 km2 southwest of Dar es Salaam. It is found between latitudes 39° 03‟ 38" E and 39° 06‟ 80" E and longitudes 6° 52‟ 00" S and 6° 08‟ 20" S. Pugu Forest Reserve is among coastal forests in Tanzania with a characteristic pattern of inner tropical region with large diurnal temperature oscillations with small amplitude in the course of the year. Meteorological data of Coast Region show a peak annual rainfall of 2385 mm and minimum rainfall of 502 mm which once occurred between 1936 and 1970 (Clarke and Dickinson, 1995).Topographically, Pugu Forest Reserve has a complex landscape with valley bottoms, dry ridge tops and intermediate undulating landscape. The existence of various topographies contributes to the heterogeneous vegetation communities in the forest (Bussmann, 2001). In terms of accessibility, the Dar es Salaam-Manero mango road that passes through Kisarawe town is the main spine that links between Dar es Salaam and settlements in Kisarawe District ( Rock and Mlingo, 2011)

**Sampling Design and Sample size**

3.2.: Sampling Techilnique: Sampling technique that involves selecting randomly selection of the study plots into the stripped transects in both sides of the railway walking to about 200m away from the axis of the project (SGR). Establishing the sub-plots from the plots with 20 meters squares. Hence, we will be identifying and recording species from the subplots. These plots will be 20 meters away from each other and each transect will be separated by 30metre from each other.

**Figure 01: Map where SGR Across the Pugu Hills Forest Reserve**

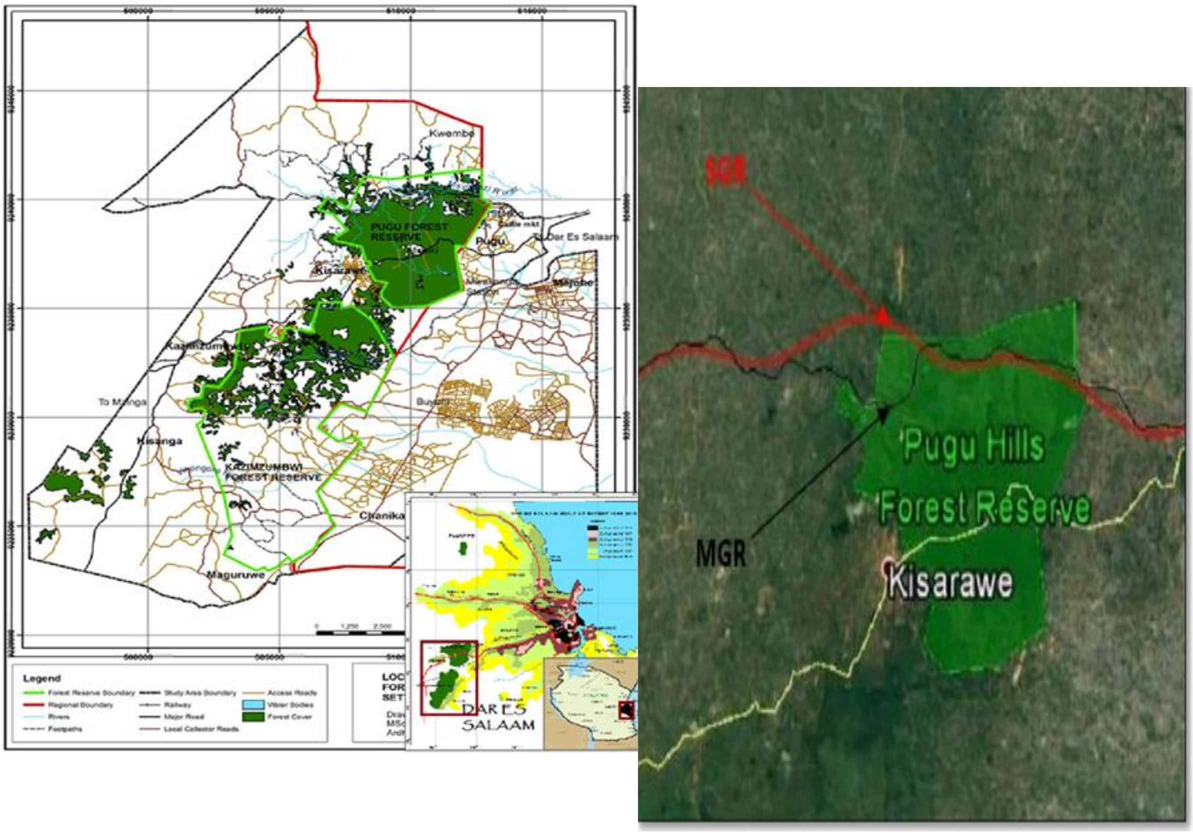
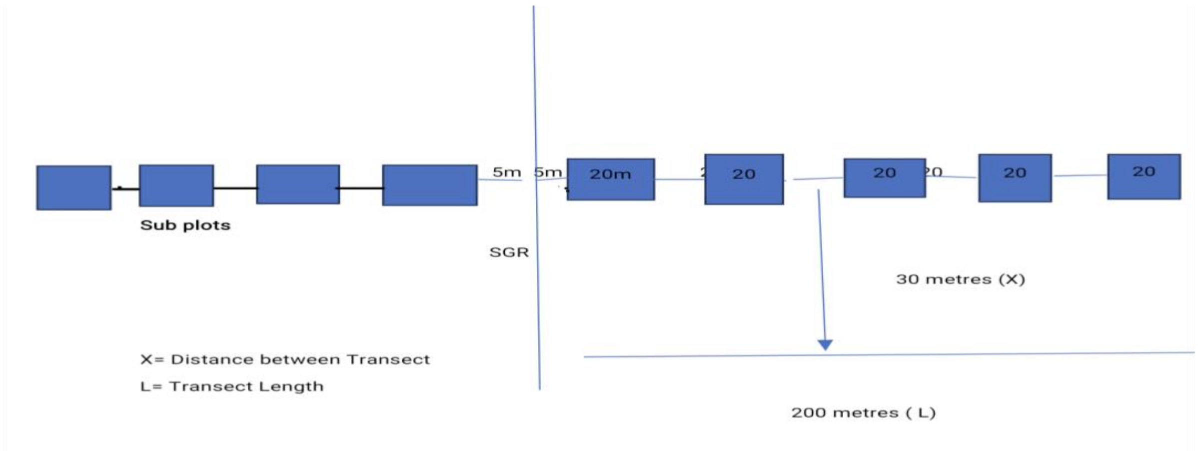



**Figure 02: Sampling Technique Conducted in the Study Area**




**Data Collection**

The ways of collection of data will be based on the targeted study area in Kisarawe district at Pugu hill forest reserve where the diversity of species is estimated to be high. The observation guide and recording of flora and fauna species communities living at a distance of 200m on both sides of the central anthropogenic object ( railway )will be done.

**Observation:** Observation method which will involve both direct observation that will be conducted through walking a distance of 200m away the railway to both sides of railway. The name of an organism seen, its species name and the number of organisms observed. Likewise in the indirect observation the signs of different species of fauna and flora will be recorded, signs like dungs of animals, fecals of birds or sounds of birds, prints of different animals. The habitats of floras like nests of birds. In the table of results, it will be recorded as seen ( direct observed ) and unseen or heard for birds in the indirect observation.

**Interviews:** Interviews will be conducted by consulting the indigenous citizens nearby the Pugu hill forest reserve from where the railway is constructed, livestock keepers and farmers bordering besides the project to identify vegetation changes of the plant species after the construction of project, consulting the ward leaders from the settlement of Pugu.

**Data Analysis**

The ordering of data collected into constituent parts will be conducted by entering the data into the excel spread sheet and analyses by using descriptive statistics. The analysis will involve grouping the flora and fauna communities which are collected from the different sample plots of the site into their species to compute the diversity indices to identify their diversity. The diversity index that will be used to determine species diversity from the data obtained is known as Shannon‟s diversity index. (Shannon and Weiner, 1948) as follows:

Shannon diversity Index( H') = - Summation ( pi Inpi)

$$H' = -\sum p_i \ln p_i$$

Where pi = ni/N, the number of individuals found in the ith species (ni) as a proportion of the total number of individuals found in all species (N).

In = natural logarithm to base e. The assumption underlying this formula can be confirmed when there is a proportionate distribution of plant s. The Shannon -Wiener diversity index assumes that individual species are sampled randomly from an even larger population, and that each representative sample species has an equal chance of being included at each sampling point (Magurran, 2004). However, species diversity will determine separately for each plot and the mean diversity was calculated from the indices by stand. Species evenness is a description of the distribution of abundance across the species in a community( Pyron, 2010). Evenness approaches zero as relative abundances vary. Species evenness can also be described using indices (Pielou,1975).Evenness (E) will calculate using the following formula (Alatalo, 1981):

Evenness(E) = H'/ In S

Where H' is the Shannon-Weaver diversity index and S is the total number of species at a site.

**Results**

In this study, we examined and evaluated the distribution and abundance of various flora and fauna species across five plots situated at different distances from a railway. A total of 745 individual plants, representing 93 species, were identified. Additionally, 61 fauna species were recorded, with a cumulative abundance of 156 individuals. The percentages of relative abundance of species collected were evaluated across all plots and presented in Tables 1 and 2 below. These tables indicate the contribution of each species to the total flora and fauna composition in each plot. Specifically, the tables provide data on the abundance of flora and fauna species in plots located at 20-40m (plot 01), 60-80m (plot 02), 100-120m (plot 03), 140-160m (plot 04), and 180-200m (plot 05) away from the railway line, showing the relative percentage contribution of each species to the total abundance of flora and fauna.

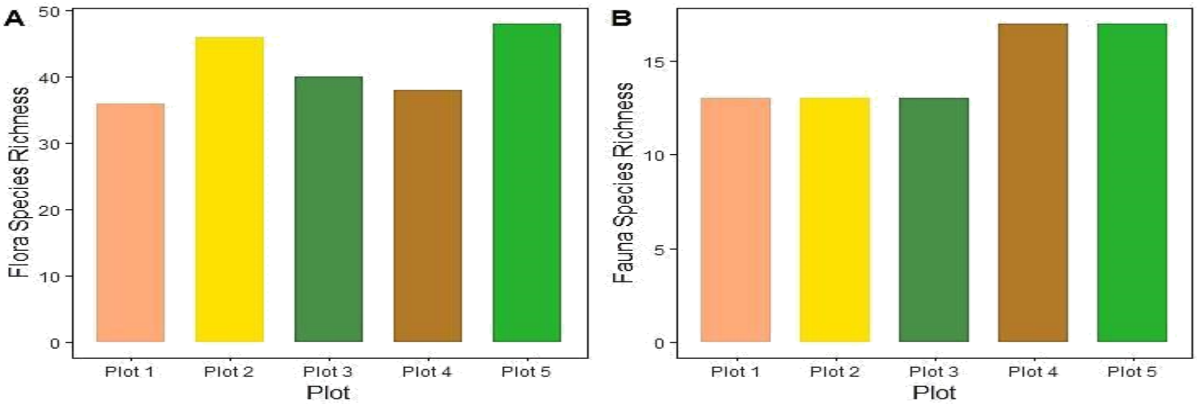
Among flora species, Cynodon dactylon, Cymbopogon citrus, and Waltheria indica were the most abundant across all plots. Cynodon dactylon exhibited the highest overall abundance with 142 individuals, making up 19.03 percent of the total species composition. This was followed by Cymbopogon citrus, with 52 individuals contributing 6.97 percent, and Waltheria indica, with 37 individuals contributing 4.96 percent. These total counts and percentages highlight the variation in species composition along the gradient from the railway. Concerning fauna, houseflies were the most abundant with 19 individuals, contributing 12.18

percent to the overall species composition. Honey bees, represented by 6 individuals, contributed 3.85 percent, and butterflies also had 6 individuals, contributing 3.85 percent to the overall species composition.

**Species Richness of Flora and Fauna**

The bar plots in Figure 1 display the species richness of flora and fauna across five different plots at varying distances from the railway. The flora species richness (Figure 1A) ranges from 36 in Plot 1 (20-40m) to 48 in Plot 5 (180-200m) away from the railway line. The fauna species richness (Figure 1B) is lower, ranging from 13 in Plot 1 (20-40m), Plot 2 (60-80m) and Plot 3 (100-120m) to 17 in Plot 4 (140-160m) and Plot 5 (180-200m). The data indicated that both flora and fauna species richness tend to increase with distance from the railway.

**Figure 03: Species Richness of Flora and Fauna**




**(A) Flora species richness across different plots (B) Fauna species richness across different plots from 20 m to 200 m away from the railway with interval distance of 20 m between plots**

**Shannon-Wiener Diversity Indices**

Shannon-Wiener Diversity Indices, richness and evenness of flora and fauna along the SGR in five plots from 20m to 200m away from the railway. The results from the study illustrate notable variations in species richness, abundance, diversity, and evenness of flora and fauna across plots located at increasing distances from the railway. In terms of flora species richness, the number of species ranged from 36 to 48 across different plots, with corresponding fluctuations in abundance and diversity indices, measured by the Shannon-Wiener diversity index (H') which ranged from 3.221 to 3.752, and evenness (e^H/S) from 0.6447 to 0.8876. Conversely, for fauna, species richness varied from 13 to 17, alongside changes in abundance and diversity indices (H') ranged from 2.328 to 2.986), and evenness (e^H/S) from 0.7888 to 1.165 (Table 1 and 2)

**Table 01: Species Richness and Diversity Indices of Flora**

| | **Plot Number (distance from the railway)** | | | | |
|---|---|---|---|---|---|
| **Plots- For a** | **Plot 1** | **Plot 2** | **Plot 3** | **Plot 4)** | **Plot 5** |
| Species richness | 36 | 46 | 40 | 38 | 48 |
| Abundance | 129 | 152 | 175 | 145 | 145 |
| Shannon-Wiener diversity jndex (*H'*) | 3.221 | 3.484 | 3.25 | 3.332 | 3.752 |
| Evenness_e^H/S | 0.6959 | 0.7087 | 0.6447 | 0.737 | 0.8876 |

**Table 02: Species Richness and Diversity Indices of Fauna**

| **Plots- Fauna** | **Plot number (distance from the railway)** | | | | |
|---|---|---|---|---|---|
| | **Plot 1** | **Plot 2** | **Plot 3** | **Plot 4** | **Plot 5** |
| **Species richness** | 13 | 13 | 13 | 17 | 17 |
| **Abundance** | 30 | 25 | 38 | 30 | 33 |
| Shannon-Wiener diversity jndex | 2.484 | 2.446 | 2.328 | 2.986 | 2.793 |
| (*H'*) | | | | | |
| **Evenness_e^H/S** | 0.922 | 0.8879 | 0.7888 | 1.165 | 0.9609 |

**Variation in Abundance of Flora and Fauna Across Plots Adjacent to a Railway**

The Kruskal-Wallis tests were conducted to evaluate the variation in abundance of flora and fauna across plots located at distances ranging from 20m to 200m from the railway line. For flora, the Kruskal-Wallis test yielded a significant result ($\chi^2 = 9.9451$, df = 4, p = 0.041), indicating statistically significant differences in abundance among the plots. Similarly, for fauna, the Kruskal-Wallis test also showed a significant result ($\chi^2 = 9.9856$, df = 4, p = 0.0387), suggesting significant variation in abundance across different distances from the railway.

**Linear Regression Analysis Results: Relationship Between Distance from Railway and Abundance and Richness of Flora and Fauna**

A linear regression analysis was conducted to examine the relationship between distance from the railway and the abundance and richness of flora and fauna. The model was specified as follows:

**Flora: Analysis of flora abundance relative to distance from railway**

The analysis reveals a statistically significant relationship between distance and flora abundance. The positive coefficient for distance (0.1250) suggests that as distance increases, flora abundance tends to rise. However, the model's explanatory power is limited, indicated by the low Adjusted R-squared value (-0.2587), which suggests that distance alone may not explain a substantial portion of the variation in flora abundance observed, possibly additional variables may be needed to better understand the factors influencing flora distribution in relation to distance from a reference. Summary of the model coefficients in Table 5, illustration of the relationship in figure 02 A below

**Table 03: Regression Analysis Summary Results of the Model Coefficient (Flora Abundance)**

| Variable | Estimate | Std. Error | t value | Pr(>\|t\| |
|---|---|---|---|---|
| (Intercept) | 156.7000 | 19.6616 | 7.970 | 0.00412 |
| Distance (m) | 0.1250 | 0.2964 | 3.9626 | 0.0034 |

Residual standard error: 18.75 on 3 degrees of freedom, Multiple R-squared: 0.05596, Adjusted R-squared: -0.2587, F-statistic: 7.5230 on 1 and 3 DF, p-value 0.0034 4.3.2.2 Analysis of flora richness relative to distance from railway

The regression model explained 65.77 percent of the variance in species richness, as indicated by the coefficient of determination ($R^2 = 0.6577$). However, the adjusted $R^2$ (-0.02969) suggests that the model fit could potentially be improved. The F-statistic (F = 11.2801, p = 0.0065) indicates that the overall model is statistically significant, suggesting that distance from the railway has a significant effect on flora richness in plots located between 20 meters and 100 meters from the railway. Based on the analysis, distance from the railway significantly explains the variation in species richness observed (SE = 0.080, t = 3.892, p = 0.0065). Summary of the model coefficients in Table 6, illustration of the relationship in figure 02 B below

**Table 04: Regression Analysis Summary Results of The Model Coefficient (Flora Species Richness)**

| Variable | Estimate | Std. Error | t value | Pr(>\|t\| |
|---|---|---|---|---|
| (Intercept) | 37.700 | 5.289 | 7.128 | 0.00568 |
| Distance (m) | 0.075 | 0.080 | 3.892 | 0.0065 |

Residual standard error: 5.043 on 3 degrees of freedom, Multiple R-squared: 0.6577, Adjusted R-squared: -0.02969, F-statistic: 11.2801. on 1 and 3 DF, p-value: 0.0065# Linear model for total abundance

**Fauna: Analysis of fauna abundance relative to distance from railway**

The regression analysis reveals a statistically significant relationship between distance from the railway and fauna abundance. The positive coefficient for distance (0.05500) suggests that for every additional meter away from the railway, fauna abundance increases by an estimated

0.055 units, with this relationship being statistically significant (p-value of 0.0139). Despite this significance, the model's explanatory power is limited. The Multiple R-squared value (0.1333) and the negative Adjusted R-squared value (-0.1557) indicate that distance alone does not explain a substantial proportion of the variation in fauna abundance. The F-statistic of 5.7270 supports the model's significance, yet highlights its limited fit to the data. Summary of the model coefficients in Table 7, illustration of the relationship in figure 02 C below

**Table 05: Regression analysis summary results of the model coefficient (Fauna abundance)**

| Variable | Estimate | Std. Error | t value | Pr(>\|t\| |
|---|---|---|---|---|
| | | | | |
| **(Intercept)** | 27.90000 | 5.37184 | 8.194 | 0.001032 |
| **Distance (m)** | 0.05500 | 0.08098 | 5.194 | 0.0139 |

Residual standard error: 5.122 on 3 degrees of freedom, Multiple R-squared: 0.1333, Adjusted R-squared: -0.1557, F-statistic: 5.7270 on 1 and 3 DF, p-value: 0.0139

### Analysis of Fauna Richness Relative to Distance from Railway

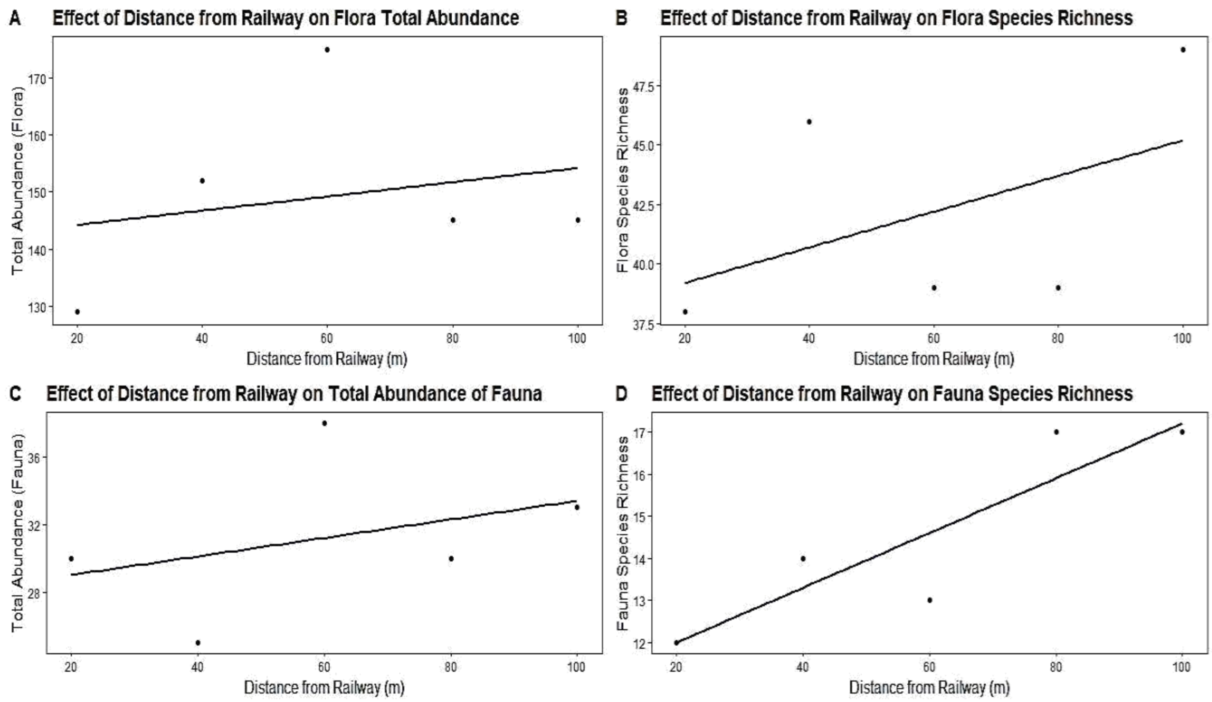
The regression analysis indicates a statistically significant relationship between distance and fauna richness. The coefficient for distance (0.06500) indicates that for every additional meter away from the reference point, fauna richness increases by an estimated 0.065 units, which is statistically significant with a p-value of 0.04142. The model shows a good fit to the data, with a Multiple R-squared value of 0.7972 and an Adjusted R-squared value of 0.7296. These values suggest that distance explains a substantial portion of the variation in fauna richness. The F-statistic of 11.79 further supports the model's significance. Summary of the model coefficients in Table 8, illustration of the relationship in figure 02 D below

**Table 6: Regression Analysis Summary Results of The Model Coefficient (Fauna Richness)**

| Variable | Estimate | Std. Error | t value | Pr(>\|t\| |
|---|---|---|---|---|
| **(Intercept)** | 10.70000 | 1.25565 | 8.521 | 0.00412 |
| **Distance (m)** | 0.06500 | 0.01893 | 3.434 | 0.04142 |

Residual standard error: 1.197 on 3 degrees of freedom, Multiple R-squared: 0.7972, Adjusted R-squared: 0.7296, F-statistic: 11.79 on 1 and 3 DF, p-value: 0.04142

**Figure 04: Showing the relationship of abundance and richness of flora and fauna from the railway at the distance interval of 20m to last plot at 200m away from the railway.**



## Conclusion

In conclusion, the study offers valuable data on how railways influence ecological patterns, emphasizing the need for targeted conservation and management practices to mitigate these impacts especially in the protected areas. The findings illustrate several ecological implications regarding species distribution and abundance. The dominance of disturbance-tolerant species like Cynodon dactylon and houseflies reflects their high resilience and adaptability to disturbed habitats. This resilience, however, comes at the cost of reducing overall biodiversity as more sensitive species may be displaced or diminished in numbers. The gradient from close proximity to the railway to further away provides insights into the distance-related effects on species composition, with areas closer to the railway generally favouring more disturbance-tolerant species. In contrast, areas further from the railway tend to support species that are more sensitive to habitat disruption, suggesting that even small distances can significantly impact species distribution.

## Recommendations

Based on the comprehensive analysis of ecological parameters across flora and fauna in relation to railway proximity, several recommendations has been drawn.

### Management and Conservation Recommendations

To effectively mitigate the negative impacts of railways on biodiversity, the following strategies should be prioritized:

**Buffer Zone Establishment:** Implementing buffer zones with native vegetation along the side of the railway infrastructure and surrounding habitats can minimize disturbance effects. These zones can act as refuges for diverse fauna, providing critical habitat and corridors for movement, thereby enhancing ecosystem connectivity and promoting biodiversity conservation.

**Habitat Restoration**: Restoration efforts in disturbed areas should focus on re-establishing native plant species and creating suitable habitats for fauna. Restorative actions aim to enhance biodiversity by recreating natural habitat conditions that support a wide range of species, thereby promoting ecosystem resilience and mitigating the impacts of railway infrastructure on local ecosystems.

**Vector Control:** Implement measures to control the creation of breeding sites for vectors, such as houseflies, to prevent the transmission of vector-borne diseases in the surrounding communities. This can be achieved through effective waste management, proper disposal of organic matter, and maintaining clean environments around railway stations and high-traffic areas.

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